# The Pipeline
## Facts From DIPRA

dipra
Ductile Iron Pipe Research Association

## The Truth About Uni-Bell's Technical Brief on Cement-Mortar Lined Pipe

The combined effectiveness of the cement-mortar lining and the larger inside diameter of Ductile iron pipe results in less energy being required to pump through Ductile than it does through PVC pipe[1,2,3]. This savings in energy occurs over the most important part of a pipeline's service life – the operations phase. This phase overwhelms the manufacturing and installation phases, combined, because we expect our pipelines to serve for generations. This explains the Uni-Bell PVC Pipe Association's (Uni-Bell) compulsion to disparage cement-mortar linings (CML), but not the carelessness of their attempts to do so. In their recent technical brief on the Hazen Williams C factor for CML, they mischaracterize references and cherry pick data – even citing data that isn't related to CML performance.

**Below is a table that provides facts related to the many false claims found in the Uni-Bell document.**

| FALSE CLAIM | FACT |
|---|---|
| **"DIPRA's Testing Conflicts with its Own Recommendation"**<br>• "A 12-inch cement-mortar lined iron pipe in Baltimore, MD had a degradation rate of 0.22 per year."<br>• "A 12 inch cement-mortar lined iron pipe (sic) Greenville, TN had a degradation rate of 0.46 per year."<br>• "Pipes from six other cities…showed declines between 0.22 and 0.46 per year." | DIPRA reported the results of 43 *in situ* **measurements of C values for in-service pipelines** from 20 cities with pipes ranging in age from 5- to 77- years in service[4]. In these tests, the head loss was measured for discrete lengths of pipeline, taking care to minimize the effects of minor losses from fittings, to determine the C factor for those pipelines. The resulting C values range from a low of 130 to a high of 148, with the average result being C = 140, which is the basis for DIPRA's recommended C factor.<br><br>Uni-Bell's calculation for the degradation of the C value is absurdly premised. Uni-Bell takes the measured results for 8 of the 42 C factors, subtracts each value from the average result of 140 and divides by the age of the pipe. So, based on only one reading in Baltimore, MD, Uni-Bell divines a degradation rate. The calculation is: (140 – 136)/18 = 0.22<br><br>Similarly, for Greenville, TN: (140 – 134)/13 = 0.46<br><br>However, in Greenville, TN, DIPRA has conducted three such flow tests, with the following results:<br>• At age 13, C = 136<br>• At age 29, C = 137<br>• At age 36, C = 146<br><br>Unsurprisingly, Uni-Bell purposely reported the C- value from Greenville, TN that would give the worst result. However, using the flawed Uni-Bell method, the results for Greenville, TN indicate the C value is improving over time and, at age 36, the C value in Greenville, TN resulted in a CML that is improving at a rate of 0.17 per year! |

| FALSE CLAIM | FACT |
| --- | --- |
| | DIPRA's tests provide definitive indications of the long-term effectiveness of the cement-mortar lining. The problems associated with unlined metal pipe were solved with the addition of the cement-mortar lining. Moreover, the value of cement-mortar linings has been documented time after time, including in several references cited by Uni-Bell in this technical briefing.[5,6,7,8,9,10,11,12,13] |
| **"Hudson – consulting firm performed "C" factor tests on metallic pipe water mains which showed significant declines in 7 cities."** | Hudson[14] references tests that measure C values, but he does so without explicit regard to the lining, and makes statements in support of the longevity of CML:<br>• "If individual C values (in Denver) for…cement lining were shown, it would be apparent that after 40 years of service, such mains retained their high carrying capacity, the average values being 130-135."<br>• "The trend line of the C values for Atlanta…substantiates, along with those for the other sites, the theory that, **in ferrous pipes without permanent lining**, tuberculation takes place…(emphasis added)"<br>• "The trend curve of C values (in New Orleans)…shows that… **the mains without permanent lining** lost approximately 25% of their carrying capacity (emphasis added)." |
| **"Army Corps of Engineers – developed equation for determining "C" values for corrosion-prone pipe at any age based on roughness growth rate."** | Uni-Bell references an article by Sharp and Walski[15] where we find, in the introductory paragraphs,<br>• "The equations presented provide a quick method for predicting C-factors (internal roughness) **in unlined metal pipes** (emphasis added)"<br>• "In modern cement-mortar lined and plastic pipes, internal roughness changes very slowly over the life of a pipe…" |
| **"Common Pipe Flow" – authors confirm "C" factor deteriorates for cement-mortar lined iron pipe."** | This references an article by Peter A. Lamont[16] who recognized modern theory of flow in pipes by noting that some pipes are "hydraulically smooth" where the values of C are essentially the same for all "smooth" pipes and are not affected by age. In Table 2 of his article, he listed a C factor for "hydraulically smooth" "spun cement-lined" pipe to vary between 147 and 153 depending on the size of the pipe – not the age. All of the deteriorating C values presented (which were the only ones Uni-Bell used) were for "uncoated cast iron." |
| **"Pump Handbook – lists "C" factor values based on age and deterioration."** | Uni-Bell cites the Pump Handbook by Karassik, *et al*[17]. In the 2008 Edition we find Table 2 on page 11.36, "Values of Friction Factor C to be Used with the Hazen Williams formula" and the following:<br>• **"Concrete or concrete lined, centrifugally spun"** (emphasis added) pipe is assigned a C value of 135 and this value is the same regardless of the age of the pipe. |
| **"The assumption of the head loss being constant for DI pipe throughout the life is an incorrect assumption. Hazen Williams factor and the effective diameter decrease with time due to internal corrosion and tuberculation in the DI pipe."** | The quote is from a master's thesis written by Mayank Khurana at Virginia Tech in 2017[18], but the thesis does not attribute a declining C factor for cement-mortar linings. The quote, itself, does not address cement-mortar lined pipe and the thesis presents no data or analysis that leads to such a conclusion. |

# Comparative Flow Tests – Cement-Mortar Lined Ductile Iron Pipe and PVC Pipe

DIPRA understands the significance of the results of the many field tests that have been performed on cement-mortar lined iron pipe. They demonstrate the general reliability of the cement-mortar lining over time and the "tightness" of the data is impressive.

## Ductile Iron versus PVC Comparative Flow Tests

DIPRA has conducted side-by-side testing of *in situ* PVC and CML Ductile. Tests were performed in Blackwood, NJ[19], Dothan, AL[20] and Wister, OK[21]. The results demonstrated the energy advantages to pumping through CML Ductile Iron pipe, as shown below:

**Flow Test Results: Cement-Mortar Lined Ductile Iron Pipe versus PVC Pipe**

| Location | Year Installed | Year Tested | Pipe Size (in) | Flow Rate (gpm) | Pipe Material | Measured Inside Diameter (in) | C Factor | Velocity (f/s) | Headloss (f/1000f) |
|---|---|---|---|---|---|---|---|---|---|
| Blackwood, NJ | 1976 | 1986 | 12 | 750 | CML DI | 12.20 | 131 | 2.1 | 1.4 |
| | | | | | PVC | 11.53 | 138 | 2.3 | 1.6 |
| Dothan, AL | 1981 | 1986 | 12 | 750 | CML DI | 12.28 | 137 | 2.0 | 1.2 |
| | | | | | PVC | 11.65 | 140 | 2.3 | 1.5 |
| Wister, OK | 1969 | 1999 | 18 | 1000 | CML DI | 18.53 | 139 | 1.2 | 0.3 |
| | 1998 | 1999 | | | PVC | 17.08 | 141 | 1.4 | 0.4 |

Note the measured C values for each pipe material, above, as well as the actual measured inside diameters of the pipes. When normalized for flow, it is clear that there is a distinct advantage in energy savings when pumping water through cement-mortar lined Ductile Iron pipe compared to PVC pipe.

## References


**1** A. Thomas, *et al*, "A Framework to Evaluate Life Cycle Costs and Environmental Impacts of Water Pipelines," *Proceedings, ASCE International Pipelines Conference*, American Society of Civil Engineers, 2016.
**2** D. McPherson, "Choice of Pipeline Material: PVC or DI Using a Life Cycle Cost Analysis," *Pipelines 2009 Proceedings*," American Society of Civil Engineers, 2009, pages 1342-1354.
**3** R. Bonds, "Cement Mortar Linings for Ductile Iron Pipe," *Ductile Iron Pipe Research Association*, 2017.
**4** Ibid.
**5** "Product and Material Information and Guidance for Water Supply Code of Australia – WSA 03-2002," *Water Services Association of Australia*, November 22, 2002, pg. 10.
**6** S. Hall, "Corrosion Protection Provided by Mortar Lining in Large Diameter Water Pipelines After Many Years of Service," *Pipelines 2013 Proceedings*, American Society of Civil Engineers, 2013, page 111.
**7** T. Muster, *et al*, "Life Expectancy of Cement Mortar Linings in Cast and Ductile Iron Pipelines," *Water Research Foundation and Commonwealth Scientific and Industrial Research Organisation*, 2011, page 128.
**8** T. Muster, *et al*, "Cement Mortar Linings in Cast and Ductile Iron Pipes: Life Expectancy and Dependence Upon Water Chemistry," *Proceedings of the 18th International Corrosion Conference* 2011, page 11.
**9** G.E.Welch and D.E. Hattersley, "Report on Cement-Mortar Lined Cast Iron Pipes," *University of New South Wales*, November, 1971, page 22.
**10** W. Sharp and T. Walski, "Predicting Internal Roughness in Water Mains," *Journal of the American Water Works Association*, November 1988, page 34.
**11** R. Bonds, "Cement Mortar Linings for Ductile Iron Pipe," *Ductile Iron Pipe Research Association*, 2017.
**12** P. Lamont, "Common pipe flow formulas compared with the theory of roughness," *Journal of the American Water Works Association*, May 1981, pp. 274-280.
**13** I. Karassik, *et al*, "Pump Handbook," *McGraw-Hill Companies, Inc.*, Fourth Edition, 2008, Chapter 11.
**14** M. Gaston, *et al*, "Pipe Inside Diameter Key to Energy Efficiency," *Journal of the American Water Works Association*, June 2014, pp 42-50.
**15** W. Sharp and T. Walski, "Predicting Internal Roughness in Water Mains," *Journal of the American Water Works Association*, November 1988, pp. 34-40.
**16** P. Lamont, "Common pipe flow formulas compared with the theory of roughness," *Journal of the American Water Works Association*, May 1981, pp. 274-280.
**17** I. Karassik, et al, "Pump Handbook," *McGraw-Hill Companies, Inc.*, Third Edition, 2001, Chapter 11.
**18** M. Khurana, "A Framework for Holistic Life Cycle Cost Analysis for Drinking Water Pipelines," *Virginia Polytechnic Institution and State University*, Masters Thesis, 2017.
**19** "Report on Flow Test: 12-inch Ductile Iron Pipe & 12-inch PVC Pipe, Blackwood, NJ," *Ductile Iron Pipe Research Association*," May 14, 1986.
**20** "Report on Flow Test: 12-inch Ductile Iron Pipe & 12-inch PVC Pipe, Dothan, Alabama," *Ductile Iron Pipe Research Association*, February 25-26, 1986.
**21** "Report on Flow Test: 18-inch Ductile Iron Pipe and 18-inch PVC Pipe; Poteau Valley Improvement Authority, Wister, OK," *Ductile Iron Pipe Research Association*, October 19, 1999.